Our Ref.: **2466-100**

U.S. PATENT APPLICATION

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Invention: AN EFFICIENT ELECTRICITY SYSTEM

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SPECIFICATION

TECHNICAL FIELD

The present invention relates to an electricity system, and more particularly to a system for using the resources in an electricity system more efficiently. The invention also relates to a deregulated electricity market including different marketplaces for trading physical electricity.

BACKGROUND OF THE INVENTION AND PRIOR ART

A major purpose of a marketplace/trading exchange for commodities is to provide a central meeting point where people can buy and sell different commodity contracts. The people buying and selling at the market place are usually referred to as investors.

The prices determined at the marketplace are generally interpreted as the "market value" of a particular contract. A marketplace for commodities in most cases attracts two different kinds of investors, hedgers and speculators.

Hedgers are people who invest money in a future contract to reduce the impact of future price changes in the market or to ensure access to a particular commodity in the future. Speculators, on the other hand, are people who invest money in the market when they see an economic benefit from it. For example, if a speculator is of the opinion that the price for a particular commodity contract is too high or too low, he may enter the market and buy or sell contracts in that particular commodity hoping to gain money from his transaction(s).

The presence of speculators in the commodity market makes a positive contribution since liquidity in the market increases. Also, any "wrong pricing" in the market will be corrected by speculators, thereby enabling hedgers to hedge the market at a price, which is regarded as fair.

A commodity market that so far has had problems in attracting speculators is the electricity market. Thus, today, were electricity is deregulated, electricity can be traded at different types of marketplaces. Contracts can be traded for short and long term periods. In both a sell and buy situation it can be necessary to hedge against price fluctuations.

A well working marketplace will need to have active sellers and buyers were both parties are able to influence the market. In countries, where the market is deregulated, former monopoly companies still have a dominating role. Production companies are often in a position where

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they can use their position to set prices in the short-term contracts. This is particularly true for the real time balancing market, sometimes termed the regulating market.

The consumption side normally has no influence on the real-time price and settlement will not take place based on the real time price, but the expected real-time price will have some impact on the spot prices.

As a consequence, existing electricity markets more or less have failed to attract speculators, and there is therefore a need for a market where both sides will have the power to influence the real-time price as well as spot prices. This will ensure that prices, at which contracts are traded, are regarded as fair prices, which are not easy to manipulate. When this is the case the market place will attract all type of investors, including speculators

A deregulated electricity market includes a marketplace to trade spot contracts (day ahead and/or on the day). Spot contracts are for delivery usually during one hour, sometimes shorter such as during one half-hour. In addition there is a balancing market which is used by the grid operator to balance/regulate the physical electricity flow on the grid. The members on this market are those who can regulate up/down on very short notice and for short delivery periods, for example 5 minutes. This market is dominated by the big production companies and has only one buyer, the grid operator.

Furthermore, in a deregulated market there is a possibility for the consumer to choose supplier. However, delivery contracts are drawn up in a way that the consumer will not be affected by the actual (real-time) price and thus he will have no incentive to increase/decrease his consumption. For example, if the real time price increases from 10 cent per kWh to one dollar per kWh, the consumers will not have the possibility to shut off consumption and get paid the real time price. Neither can they increase their momentary consumption and benefit if the real time price drops to 5 cents per kWh.

The overall goal when designing an electricity system is to make the electricity market as efficient as possible. If the profit is bigger to reduce consumption instead of increase production the investments should be done on the consumption side and of course the opposite if there is more profit in building new production units.

In conclusion, where the electricity market is deregulated today, it is still very inefficient. This is mainly due to these main factors:

- A very strong position for a few very large companies controlling the real-time prices (balancing market), and the prices at the balancing market will influence prices at spot market.
- The spot market prices are usually been used to close open financial positions in longer contracts leading to a lack of speculators providing the market with liquidity, and
- The lack of incentive for the consumers to act on real-time price changes in the market will not break up the situation.

SUMMARY

It is an object of the present invention to provide an improved and more efficient electricity system, and to create a marketplace were both production and consumption can react on changes in real time prices.

This object and others are obtained by the present invention as set out in the appended claims.

Thus, in order to build an effective electricity system, it is essential that the short-term prices show the actual "value of electricity" so that producers and consumers can react on these prices. To create an electrical system were both the buy and sell side can react on price information requires an infrastructure that supports both sides with actual price information.

In the case when electricity is traded on exchanges, price information will be available for the members and those who have access to the information system. The prices set by an exchange provide the exchange members with a tool that they can use for determining how to run their business in the most cost efficient manner.

For example, a process industry could choose to only perform very energy demanding tasks if the electricity price is at a level where process can be carried out with profit. As another example, a manufacturer could choose to use another way to produce steam by gas or oil if the electricity price is over a certain level.

However, today there is no infrastructure in place to support different types of electric equipment with actual price information. This means there is no way to program equipment

using electricity to react on actual price information. The electricity systems today are designed based on the fact that electricity cost a fix price, normally the same price all over the year or a price that can vary a little between seasons or between day/night. Thus, today the producers have the market power especially in situations with limited production capacity compared to the demand.

In order to overcome this shortcoming, end consumers must be enabled to adapt their power consumption with respect to the current electricity price, and to receive a substantial economic benefit from doing so. In that case, the entire electricity market will become more efficient. This in turn will lead to that electricity will be produced and consumed in a way, which minimises the overall cost. The real time price fluctuation as well as spot prices will also be lower in extreme situations. In the long run this will create a marketplace where, as opposed to the existing systems, both seller and buyer will have impact on the price.

In accordance with a preferred embodiment of the present invention such an electricity system is obtained by feeding real time price as well as spot price information from a price information dissemination unit to the equipment or the meter-central and charging the consumer a price corresponding to the real-time price. The end consumer will hedge his electricity price but also control his/her physical power consumption based on the real-time price for electricity. Thus, the end consumer can take advantage of low prices as well as reduce or move consumption from periods where the price exceeds some limit. Even if the consumer don't participate in the balancing market the price on that market will drop if the situation changes from a need to increase production to a situation were the production will decrease.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described in more detail by way of non-limiting examples and with reference to the accompanying drawings, in which:

- Fig. 1 is a general prior art view of a deregulated electricity market including different entities and functions.
- Fig. 2 is a view of an improved electricity system illustrating the flow of price information in real time.

- Fig. 3 is a view illustrating the major parts in the system in Fig. 2 used for dissemination of real time price information.
- Fig. 4 illustrates prices for different contracts during one day for an exemplary electricity consumer, and
- Fig. 5 illustrates measured and contracted energy consumption during one day for the exemplary consumer.

DESCRIPTION OF PREFERRED EMBODIMENTS

In Fig. 1, a general view of an electricity system 101 including different entities and functions is shown. The figure includes both the physical electricity flow as well as information flow including prices and volumes.

The system 101 comprises a number of producers in the system shown, in Fig. 1 represented by Producer (or power generator) 103, which generates and sells physical electricity. The Producer 103 is connected to a common electricity grid 105 via a regional/local network 107 or directly to the grid.

The system 101 further comprises a number of consumers, which in the system shown in Fig. 1 are represented by Consumer 109. The Consumer 109 uses electricity for different purposes and is connected to the common grid 105 via a distribution network 111.

Connected to the system 101 are also a number of distributors, in the system shown in Fig. 1 represented by Distributor 113. The Distributor 113 manage (owns) the local distribution network 111 connected to the grid 105 or a regional network. Further, a number of suppliers in the system shown in Fig. 1 represented by Supplier 115 are connected to the system 101. The Supplier 115 sells electricity to consumers, such as the Consumer 109. The Supplier can for example be a production company or a trading company or in some markets the Distributor 113.

The system 101 also comprises an Exchange 119. The Exchange 119 is a marketplace where buyers and sellers of electricity contracts can meet. Contracts can be defined to cover spot contracts as well as future contract and forward contracts with delivery from a day to more than a year. The marketplace also includes the spot market covering short-term contracts of usually one hour, in some cases shorter and in some cases a block of hours. Different

electricity markets can have different rules for the spot market. Connected to the Exchange 119 are a number of traders (hedgers), here represented by the Trader 117. The Trader 117 is a party acting on the market by selling/buying electricity as physical contracts as well as financial contracts. The Exchange 119 is also connected to a number of Financial traders (speculators) 125. The financial traders 125 only buy and sell financial contracts and are hence never involved in actual delivery of electricity. The financial traders only contribute with liquidity in the Exchange 119 that constitutes the marketplace.

In the system 101, there is also a System operator 121. The system operator 121 is responsible for managing the grid 105, in particular the part of the grid designed for voltages above 150 kV. The System operator 121 is closely connected to a Balancing Market 123. The Balancing market is used to balance the difference in real time between production, consumption and losses, in addition to the automatic frequency control.

In Fig. 2, real time price information flow in the system 101 in Fig. 1 is shown. The price information distribution includes a price information dissemination unit 151 sending real-time price information broadcasts to all parties. In particular the price information dissemination unit 151 distributes real-time prices to the consumers. This can be done either directly or via the distributor. In a system were the distributor is responsible for sending price information to the consumers he can add information to the message relevant for how the distribution cost is settled.

The transport mechanism can be based on different standard components such as different types of wireless communication, power line communication, telephone lines, wide area data networks and so on.

On the consumer side the information will be received in standard equipment and used to control different electricity objects as water heater, cooling equipment, motors, lights and so on. Equipment for controlling different electricity is for example described in the UK patent application No GB 2309567 and in the U.S. patent No US 4,771,185. Real time prices (as well as spot prices) can also be displayed on a readable screen.

In Fig. 3, the infrastructure used for disseminating real time price information in accordance with the present invention is shown. The core component in the real time price dissemination

system is the unit 151. The unit 151, which can be co-located with the Exchange 119, but which of course can be located at any suitable location, preferably receives information both from the Exchange 119 and from the Balance market 123. The unit 151 receives price information from the different markets and compiles the price information into a message having a suitable format. The message is then transmitted to the intended receivers, for example the consumers and/or the distributors. The Following parameters can preferably be included in a message transmitted by the unit 151:

Information type	as price information relating to electricity
ID Information	different dissemination units can have different identities and thus be recognised by the receiver
Contract type	as real-time price or spot price
Valid for (time)	for example in the form yymmdd:hhmm to ;hhmm
price	for example cents/kWh. Also different prices for up and down regulation can be included.

The real-time prices can be different for different local areas and therefore the general message preferably also includes information regarding price per geographic area. The message can be packed as an XML-message (Extensible Markup Language) DI message (Electronic Data Interchange) or any other type of an open API (Application Program Interface.)

When the exemplary embodiments as described herein are implemented, the system can operate in the following way. Customer 109 is connected to the distributor 113 and has an electricity contract with the supplier 115. The Customer 109 further has an electricity meter that will meter electricity consumed by the customer 109.

Assuming that the consumer has an agreement involving two price-hedging contracts with a supplier, a first base contract with same power at all hours, for example a yearly contract for 10 000kWh, which means an hourly delivery of 10 000 divided by 8760 hours. The price for this is agreed to 7 cent/kWh, as is depicted in Fig. 4.

In addition the customer also has a second, peak contract for a year of 10000 kWh. The peak period covers all working days between hours 6 and 20. The peak contract will be delivered

during 70 hours a week and 3668 hours for the year. The price is set to 10 cent/kWh, as depicted in Fig. 4.

In the settlement process the customer will pay the supplier 10000*7 cents and 10000*10 cents equal to $1700 or approximately 4.66 $/day. The measured difference between his hedging contracts and measured actual consumption will be settled at the real time price. Different markets may employ different rules for what is determined to be the real-time price. The real-time price may be set to the price at the balance market or at the spot market for that particular time.

Referring to figure 4 as an example of the prices a certain day and figure 5 as an example of the contracts and the measured use of electricity on that day (the two contracts include approximately 66 kWh and measured volume is 70 kWh for the day). The settlement process will then include the cost for the price hedging contracts. In this example $4,66 and in addition the real time price multiplied with the difference between measured volume and contracted volume for each hour. It is of course possible to use any suitable time period when settling the real time prices (Minutes, Half-hours etc).

In this example the consumer will be charged 19 cent to the real-time market. The cost for real time energy can be both positive and negative depending on when the consumption occurs and how many kWh is used. Thus, when the consumer consumes more power than he has purchased hedge contracts for he will be charged the real-time price for this additional consumption. On the other hand if he consumes less power than he has purchased hedge contracts for he will have the corresponding amount deducted from his invoice from the supplier. It is to be noted that in some deregulated markets the real-time price for decreasing power generation and for increasing power generation differs. Thus, there is one price for increasing power production and another for decreasing power production. In a corresponding way there will be two prices used in the settlement. In other words consumption above the hedged contracts will be charged at one price, usually higher and consumption below the hedged price will lead to a deduction at a second price, usually a lower price.

In the system as described above it is preferred to use the real-time price set in the balancing market in the settlement, even though it would be possible to use any other price reflecting the real time price, such as the spot market prices, as an alternative.

In a system where the balancing market price is used in the settlement it is nevertheless advantageous to provide the customer with the spot market price. In other words the message transmitted from the price information dissemination unit 151 will preferably comprise both the prices at which increased power generation and decreased power generation are traded (balanced market prices) as well as the spot market prices set at the exchange. The reason for providing the spot market prices to the consumer is that in an efficient electricity market there will be a very strong correlation between the spot market price and the price at the balancing market. Hence, the spot price will provide a good indication on what the real-time price will be in the very near future. The consumer can benefit from this information by planning ahead certain power demanding activities.

Using the system as described herein will place all electricity consumers in a position where they can control their consumption pattern in response to the current price for production of electricity. The system as described herein will therefore be able to balance electricity production and electricity consumption at both sides, i.e. at the production side as well as the consumption side. In the past this was not possible since no incentive for participating in this balancing existed at the consumption side. In addition, by providing a means for the consumers to actively take part in the market, the electricity market will become more like traditional commodity markets and will hence more easily attract speculators. This in turn will increase liquidity on the electricity market, which will lead to better prices for people trading hedge contracts.